

## Supplemental Methods

We conducted a literature search on PubMed, Web of Science, EMBASE and Google Scholar for articles published before January 1<sup>st</sup> 2013 using a Boolean conjunction operation between the search terms: [ADHD\* or attention deficit hyperactivity disorder, or hyperkinetic\* or impuls\*- title and abstract] and [emotion\*, mood\*, regulation\*, or labil\* or aggress\* or temperament\*- title]. This was supplemented with bibliographic cross-referencing and discussions with experts and yielded a total of 3209 studies. Case reports, conference abstracts and letters to editors were excluded and duplicates removed, full texts were retrieved and reviewed and 168 articles were finally included. Studies were categorized by the first author according to topic: (1) symptoms and impairment; (2) pathophysiology; and (3) treatment. Treatment studies were included if they included emotion regulation as an outcome, and had a randomized allocation to either an intervention or control wings (placebo in the case of pharmacological studies).

We summarized data quantitatively where possible, selecting studies for meta-analysis if they included a measure of central tendency and variance and there were at least five independent reports of the same construct, or measures which the lead author felt measured the same underlying construct. Quantitative syntheses were possible for emotion recognition (17 studies), aggressive behavior (12 studies) and measures of reward valuation (21 studies). As all the outcomes included in the meta-analysis were continuous, we calculated standardized mean differences. We used a random effects model to generate a pooled effect size and confidence intervals (CI) with the inverse variance method. Significance was determined by the z-test and heterogeneity was assessed by the  $I^2$  method. The results of the quantitative analyses shown in Figure 1 and the remaining studies are reviewed qualitatively.

For emotion recognition the main outcome variable was the accuracy of forced choice or free labeling of facial emotional expressions **(1-15)**. In one study participants were asked to rate the valence of positive and negative stimuli taken from the International Affective Picture System (16). In the Yuill and Lyon study subjects were asked to match facial expression with a scenario (17).

Reward valuation was assessed using paradigms which assess the preference for small immediate rewards over large delayed rewards. This is usually held to reflect an aversion to delay. In the most widely used paradigm participants are asked to choose between receiving 1 point at a 2 second delay (small, immediate reward) over a reward of 2 points delivered with a 30 second delay **(14, 18-31)**. In this paradigm there is no pause between trials and thus choosing a small immediate rewards is associated with shortened trails and less overall delay. Some variants of the task include a pause following each choice to equate the inter-trial interval (18, 26).

**TABLE S1. Experimental induction of behaviors linked to emotion dysregulation. All studies contrasted children with ADHD and typically developing (TypDev) controls.**

Study	Participants	Method	Findings
Maedgen and Carlson 2000 (44)	ADHD-combined (N=16) ADHD-inattentive (N=14) TypDev (N=17)	Reaction to removal of a prize they had just won	ADHD-combined showed more aggressive and emotionally 'intense' behaviors than ADHD-inattentive and TypDev, who did not differ.
Walcott and Landau 2004 (45)	Childhood ADHD (N=26) TypDev (N=23)	Insoluble puzzle; in one condition, told to suppress response.	Degree of dysregulated behavior (e.g. shutting down, negative or disruptive behavior) greater in ADHD than TypDev, regardless of instructions to suppress responses.
Milich and Okazaki 1991 (46)	Childhood ADHD (N=23) TypDev (N=22)	Insoluble puzzle	ADHD children solved fewer puzzles overall, stopped earlier, showed more negative affect and reported more frustration.
Cole et al. 1994 (47)	79 children at high, medium or low risk for behavioral problems on basis of parent CBCL and Teacher Report Form	Behavior during receipt of an undesirable gift	Boys at high risk and girls at low risk showed more negative behaviors when they thought they were unobserved, but not when in company of an adult.
Melnick and Henshaw (48)1996	Childhood ADHD (N=27), divided into low and high aggression based on behaviors observed at summer school TypDev (N=18)	Behavior during a group competitive interaction task	ADHD with high aggression were dominant, disruptive and attention-demanding compared to ADHD with low aggression and TypDev.

Scime and Norvilitis 2006 (49)	Childhood ADHD (N=21) TypDev (N=20)	Complete a puzzle while blindfolded	ADHD more likely to quit task before completion.
Rosenbaum and Baker 1984 (50)	Children divided into high (N=27) and low hyperactive (N=22) groups on Connors Teacher Report	Strategic problem solving tasks	Hyperactive group showed decreased use of effective strategies and more negative affect.
Douglas and Parry 1994 (51)	ADHD-hyperactive-impulsive (N=30) TypDev (N=30)	Altering schedules of rewards and lever pulling to gain rewards as an index of induced frustration	ADHD reacted more 'frustrated' lever pulling ADHD showed stronger lever pulling when rewards lost.
Keltner et al 1995 (52)	Based on CBCL, children stratified into: High externalizing (N=9) High Internalizing (N=9) High internalizing and externalizing (N=12) Controls (N=40)	Facial expressions during IQ testing	High externalizing group showed more negative expressions, especially anger.

**TABLE S2. Studies linking temperament with symptoms of ADHD and emotional problems. RRR=relative risk ratio; ODD=oppositional defiant disorder.**

LONGITUDINAL				
		Time 1- temperament	Time 2- outcome	Results
Stringaris and Goodman 2009 (53)	Epidemiological N=7140	Emotionality, Sociability and activity at age 3.	DSM-IV diagnosis at age 7	ADHD predicted by early emotionality (RRR=1.26), sociability (RRR=1.33). Combined type and hyperactive-impulsive subtypes predicted by early activity (RRR 1.9 for combined and 4.25 for hyperactive). Emotionality also predicted later comorbid ADHD and internalizing disorder (RRR=1.59); Activity predicted later ADHD and ODD (RRR=3.24)
Goldsmith et al 2004 (54)	Epidemiological N=570 families	Observational measures in infancy	Kindergarten: ADHD symptoms from Health Behavior Questionnaire	Correlations between parent and teacher ADHD symptom ratings and early temperamental anger (teacher 0.24; parent 0.14); high approach (teacher 0.37, parent 0.19); anticipatory behavior (teacher 0.25, parent 0.1)
Carlson et al 1995 (55)	Epidemiological N=191 families	Carey Infant temperament questionnaire: adaptability, approachability, alertness	Hyperactive symptoms from CBCL at age 6-8 and at age 11.	Non-significant correlation between infant adaptability and hyperactivity at age 6.8 (r=0.1) and hyperactivity at age 11 (r =0.06) Early measures of cognitive style, early caregiving style and contextual factors were stronger predictors of later

				hyperactivity.
Olson et al 2002 (56)	Epidemiological N=89 families	Age 1-2 years: Observational and parent report: focused on toddler's resistance to control, fussiness, disengagement. Bayley scales: Cognitive competence	Age 8: during a range of task: observers rated a child's degree of inhibitory and behavioral control and tendency to disengage	No significant correlation between measures of inhibitory or behavioral control at age 8 and early temperament. Early cognitive competence was a stronger predictor than all temperamental measures.
Bates et al 1998 (57)	Epidemiological N=120 families	Age: 6 and 13 months Infant Characteristics Questionnaire focused on resistance to control	8 years: CBCL externalizing symptoms	Parent and teacher CBCL scores correlated with early resistance to controls (teacher $r=0.22$ ; parent $r=0.3$ ). Link was higher when mother was low in controlling behaviors
Bates et al 1998 (57)	Epidemiological N=156 families	Age: 5 years Retrospective recall of early infant temperament	CBCL-externalizing symptoms	Parent and teacher CBCL ratings correlated with early resistance to controls (teacher $r=0.14$ ; parent $r=0.32$ )
CROSS-SECTIONAL				
Healey et al 2009 (58)	Age 3-4 years Case control ADHD (N=140) Controls (N=76)	Parent rating of ADHD symptoms Teacher temperament Assessment Battery of Children Neuropsychological battery (NEPSY)		High negative emotionality associated with ADHD symptoms regardless of cognitive ability. For ADHD with low negative emotionality, high cognitive abilities impacted on level of ADHD symptoms. For typicals, high cognitive ability protected against effects of negative emotionality.
Martel and Nigg, 2006 (59)	Age 6-12 years Case control	Early Adolescent Temperament Questionnaire and California Q-sort		Negative emotionality associated with ADHD symptoms by parent but not teacher

	<p>ADHD (N=92) Symptoms of ADHD (N=35) Controls (N=52)</p>		<p>report, and with oppositional symptoms. Cognitive control style linked with ADHD domains (effortful control protected against inattention; reactive control style associated with hyperactive-impulsive symptoms). Effortful and more controlled cognitive style 'protected' against ADHD symptoms in the presence of low negative emotionality only.</p>
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